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Linking Frascati-based R&D Spending to the System of National Accounts: An Application to U.S. Data

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Abstract:

This paper provides a framework for translating research and development expenditure data organized based on the Frascati Manual to a measure of gross output consistent with *The System of National Accounts 1993*. The framework is applied to U.S. survey data on the performance of R&D from the National Science Foundation. The paper is accompanied by a set of tables detailing the translation for 2001.

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1. Introduction

A first step in capitalizing Research and Development (R&D) expenditures is to relate these expenditures as closely as possible to current national accounting conventions. The internationally accepted guidelines for these accounting conventions are found in the *System of National Accounts 1993* (hereafter SNA). Internationally comparable data on R&D activity are collected and organized by the Organization for Economic Cooperation and Development (OECD) based on a classification system described in the Frascati Manual (OECD (2002)). R&D activity can be more clearly quantified in economic terms by linking the two system, particularly useful for the purposes of capitalizing R&D expenditures. The tables that accompany this paper link R&D expenditures measured on a Frascati basis with a production account measure of gross output consistent with the SNA. This text and the accompanying tables describe the steps involved. These steps include adjusting the functional classification of transactions based on their purpose, separating current expenditure from capital formation, and sorting expenditures into the sectors used in the SNA. The resulting SNA-based accounts provide a framework for the creation of satellite accounts for R&D that avoid double-counting of capital assets. The translation of R&D activity into an investment good in a satellite account is a separate and related task not covered in this paper.

In addition to its primary purpose for the creation of R&D satellite accounts for the U.S. economy, the SNA framework provides a useful alternative view of the economic impact of R&D activity. The construction of the link focuses attention on definitional

questions about the range of activities that should be included as R&D, the nature of R&D transactions in the economy, and the economic characterization of R&D as both a market and non-market good. Finally, the link tables point to the value of the SNA framework for improving measures of the increasingly important international flows in R&D services.

This paper is organized in four sections plus a set of eleven tables. Section 1 summarizes the differences between the Frascati Manual and the SNA in terms of their purposes, their definitions of R&D, and their sectoring. Section 2 describes the sectoring framework used for this Frascati to SNA Link. Section 3 describes the translation of expenditures to gross output in general terms. Section 4 describes these translations sector by sector using U.S. source data. Section 5 concludes, and the accompanying tables provide detail on the sector by sector translation[1].

1.1. Summary of Differences between the Systems

1.1.1. **Different Analytical Purposes for two Systems**

R&D expenditures are key inputs to the process of creating new technological knowledge. They are one of many related indicators of the effort devoted to basic science and innovative activities that are used by those who evaluate science policy. The Frascati Manual provides guidelines on annual measurement of R&D expenditures and R&D personnel so that these efforts can be compared internationally. The Frascati Manual's recommendations are the basis for the OECD presentation of internationally comparable R&D expenditures for thirty countries in the publication, *Main Science and*

[1] These tables should be considered a work in progress, as some additional source data has yet to be included.

Technology Indicators (OECD (2004)). This publication presents R&D expenditures organized by the sector of the performing institution and the sector of funding institution.

The SNA, in contrast, provides a basis for internationally comparable measurement of *economic* activity within a national accounting framework. The SNA shows economic activity organized by sector through an integrated system of statements for production, income, saving, investment, and financial flows. Although the SNA recognizes that R&D activities provide future benefits and R&D is not completely used up in the production process, the SNA does not explicitly treat these activities this way. R&D is treated as current expense rather than as capital expenditure within the SNA.

The tables that accompany this paper translate R&D expenditures from a Frascati basis to an SNA measure of gross output of R&D activity by adding up the costs of production. Related efforts by Dutch and Israeli statistical agencies have led the way in translating Frascati-based expenditures to the SNA. These U.S. tables are informed by the work of Mandler and Peleg (2003, 2004) in translating Frascati-based expenditures into SNA-based measures of output of R&D as well as the industry-level accounting of gross fixed capital formation of knowledge capital by de Haan and van Rooijen–Horsten (2003, 2004).

1.1.2. **Different Definitions of R&D in the two systems**

The simultaneously private and public good qualities of R&D complicate its economic classification. R&D has the nonrival quality of a public good[2], where the use of R&D by its creator or purchaser does not prevent R&D from providing further benefits

[2] A public good has the qualities of non-rivalness and non-exclusiveness in consumption. Paul Romer's (1990) model of endogenous technological change describes the spillover from innovative activity as a non-exclusive public good that the innovating firm cannot completely capture.

to others. On the other hand, it has the quality of a private good that when created or purchased, patenting and trade secrets can render R&D exclusive in its use, at least in the short term.

R&D can be either a market good or a non-market good. It is performed by governments, non-profits, and universities as a collective consumption public good, and as such the SNA would consider it a non-market good. It is performed by R&D labs that sell their output to private firms at market prices and thus the SNA would consider it a market good. As a market good, R&D is also performed for internal use by private corporations and as such is an own-account intermediate input. The classification suggested by de Haan and van Rooijen-Horsten (2004) provides a framework that recognizes the different ways that R&D is used in production. They identify three types of R&D service commodities, these are market R&D, non-market R&D, and own-account R&D. This three-way classification is used in this paper to assign R&D to sectors, with the modification that own-account R&D can also be produced as a non-market commodity by institutions of the government sector.

As described on a Frascati basis, Research and Experimental Development ($R\&D_{FM}$) is "…creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture, and society, and the use of this stock of knowledge to devise new applications (OECD (2002) par. 63)." This definition makes it clear that in addition to R&D in the natural sciences, it also covers R&D in the social sciences and the humanities. The quality that distinguishes Frascati-based R&D from related activity is "an appreciable element of novelty and the resolution of scientific and/or technical uncertainty (OECD (2002) par. 84)." Within this framework, Frascati-

based R&D has three subdivisions, basic research, applied research, and experimental development.

The SNA, by contrast, describes rather than defines Research and Development ($R\&D_{SNA}$): "Research and development are undertaken with the objective of improving efficiency or productivity or deriving other future benefits…(CEC et al., (1994) par. 6.163)." The SNA distinguishes R&D from other related activities that also derive future benefits, such as staff training, marketing, and environmental protection (CEC et al., (1994) par. 6.163). Its purpose is identified as follows: "Research and development by a market producer is an activity undertaken for the purpose of discovering or developing new products, including improved versions or qualities of existing products, or discovering or developing new or more efficient processes of production (CEC et al., (1994) par. 6.142)." Within this context, R&D by market producers is considered primarily as an intermediate input.

The purpose of R&D for non-market producers is not clearly specified in the SNA, but it does give some guidelines on how to value it for both market and non-market producers: "(It) should, in principle, be valued on the basis of the estimated base prices that would be paid if the research were subcontracted commercially, but is likely to have to be valued on the basis of the total production costs, in practice. Research and development undertaken by government units, universities, non-profit research institutes, etc. is non-market production and is valued on the basis of the total costs incurred (CEC et al., (1994) par. 6.142)."

1.1.3. **Differences in Sectors in the two Systems**

Frascati treatment presents R&D expenditures two ways, by institutional sectors of performance and institutional sources of funds. Institutions that conduct R&D are classified into sectors based on their primary activity. There are four sectors of performance: Business Enterprise, Higher Education, Government, and Private Non-profit Institutions, and five sectoral sources of funding. The additional source of funds is from Abroad. For the most part, the Frascati sectors have a direct relationship to SNA-based institutional sectors, with a clear difference for Frascati that Higher Education is a separate sector (OECD (2002) par. 157).

SNA sectors are comprised of institutional units, which are economic entities that can own assets, incur liabilities, and engage in economic activities and transactions (CEC et al., (1994) par. 4.2). The major institutional units recognized by SNA include individuals, households, corporations, non-profit institutions, and government units.[3] Since these categories are mutually exclusive, sectoring involves assigning the units within the economy to these sectors. The SNA recommends the division of these units into major five major sectors: non-financial corporations; financial corporations; government; non-profit institutions serving households (NPISHs); and households. These sectors can be further subdivided to distinguish different types of corporations as well as levels of government. Transactions between resident units and non-resident units form an additional account, the rest of the world (CEC et al., (1994) par. 1.13).

The SNA identifies two kinds of producers, market producers and non-market producers. Market production involves goods for sale at an economically significant

[3] An important SNA-identified institutional unit not discussed here is the quasi-corporation. These are units that are grouped with corporations because their economic activities are similar, although they may be owned by different economic entities than corporations.

price, and market producers sell most or all of their output on the market. Market producers may also produce output for own account. The output of non-market producers is distributed for free or at non-significant prices or may be produced for own account. Because of R&D's characteristics as a quasi-public good, R&D activity can be either market output or non-market output.

This duality complicates the SNA sectoring task for R&D because the process of sectoring often begins with determining whether the output is market or non-market. As the SNA definition indicates, for R&D it can be either. While experienced national accountants could reasonably chose alternate sectoring schemes for R&D, this link will be built around an interpretation of the SNA that is based on the language cited in Section 1.1.2 about R&D that identifies non-market output based on the sector of the institution that produces it.

The alternative would be to identify market output based on the ratio of price to cost as a way to decide whether the price is economically significant. An economically significant price is one that has a significant influence on the amount producers are willing to supply and the amount purchasers wish to buy and is a key criterion for identifying market output (CEC et al., (1994) par. 6.45) . Since the Frascati data provides no information on price and most R&D output is valued at cost, the best assumption one could make based on Frascati expenditure data is that price is equal to cost. This alternative assumption would classify all R&D as a market good, an unsatisfactory conclusion.

By convention rather than economic theory, the SNA characterizes the final output of NPISHs as individual consumption in the final expenditure aggregates, while

the output of general government can be either individual consumption or collective consumption (CEC et al., (1994) par. 9.94). The public goods qualities of R&D allow much of the government R&D to be considered a collective consumption good. While no alternate sectoring scheme better fits R&D activity and the SNA, the scheme followed in this paper and tables does conflict with the notion of nonmarket R&D produced by NPISHs as solely an individual consumption expenditure. This NPISH-produced R&D may instead be considered final collective consumption of the general government.

2. The Sectoring Framework

The table that follows (Table A) illustrates the Frascati to SNA linking of the sectors in the worksheets that accompany this paper. Moving left to right across row one of the table, the business enterprise sector is linked to non-financial corporations and financial corporations. Row two of the table translates expenditures for R&D performed by the government sector into the output of general government on an SNA basis. Conceptually this row should include federal, state, and local government institutions as well as the non-profits that are financed and controlled by the government. The third row is the private non-profit and household sector; this sector is expanded in the SNA treatment compared with the Frascati sector because private non-profit colleges and universities are moved here from the higher education sector. The fourth row is the Frascati-based higher education sector. Since this is not a sector in the SNA, these expenditures are divided between general government and the non-profit institutions serving households (NPISH) sector. Row five illustrates the treatment of R&D activities by households. While the Frascati Manual does not have a separate sector for households,

the SNA identifies households as a producing sector. The Frascati Manual considers the market activity of households as that of an unincorporated enterprise and includes this activity with the business sector. The residual household activity, non-market activity of households, is included with the private non-profit sector (OECD (2002) par. 197). Following the Frascati convention, this Frascati-to SNA Link sectors R&D produced by households for sale in the market with the relevant corporate sector, and sectors with the Non-profit sector R&D produced by households that is not sold in the market. The final row of Table A is Abroad, and is linked to a Rest of the World sector.

Table A Linking Frascati Sectors to SNA Sectors

Row	OECD Frascati Manual	SNA	BEA's Frascati-SNA Link
1.	Business Enterprise Sector	Non-financial corporations	Non-financial corporations
		Financial Corporations	Financial Corporations
2.	Government Sector	General Government	General Government
3.	Private Non-Profit Sector	Non-profit Institutions Serving Households	Non-profits Institutions Serving Households
4.	Higher Education Sector	General Government	General Government
		Non-profit Institutions Serving Households	Non-profit Institutions Serving Households
5.		Households	Non-profit Institutions Serving Households
			Non-financial corporations
			Financial Corporations
6.	Abroad	Rest Of World	Rest of World

2.1. **Business Enterprise to Non-financial and Financial Corporations**

The Frascati-based business sector is composed of "firms, organizations and institutions whose primary activity is the market production of goods or services (other than higher education) for sale to the general public at an economically significant price." For both Frascati and the SNA this business/corporate sector includes corporations that are owned by government units but provide goods or services that are 1) mainly sold by private enterprises, 2) sold at economically significant prices, and 3) the purchase of these goods is voluntary (OECD (2002) par. 165). Included within this sector are the market activities of individuals and unincorporated businesses conducting R&D. Two kinds of non-profits are also in the Frascati-based business sector, these are the non-profits that sell their output at prices that cover most costs (economically significant prices), and non-profits that serve the business sector. In the tables that accompany this paper, all the R&D performed by corporations is considered to be market output except for the R&D performed at federally funded research and development centers administered by business. For reasons discussed below, these are assigned to the government sector.

Within the SNA, the corporate sector is subdivided into non-financial corporations sector and a financial corporations sector. Non-financial corporations are those engaged in producing market goods and non-financial services (CEC et al., (1994) par. 4.68). Financial corporations are those principally engaged in financial intermediation or closely related auxiliary financial services. On an International SIC basis these industries are in divisions 65,66, and 67.

2.2. Government to General Government Sector

The Frascati-based government sector is defined as "All departments, offices and other bodies which furnish, but normally do not sell to the community, those common services, other than higher education, which cannot otherwise be conveniently and economically provided, as well as those that administer the state and economic and social policy of the community." Additionally, NPIs controlled and mainly financed by government, but not administered by higher education are included in the government sector (OECD (2002) par. 184).

As described earlier, when the government produces goods that are normally sold by private enterprises and sells them at an economically significant prices, these goods are considered by the SNA to be market goods and should, with some qualifications, be sectored as output of the corporate sectors.[4] This SNA language has led some national accountants to consider the output of U.S. public universities to be market output and to question whether both public and private universities should be properly assigned to the corporate sector in the SNA.[5] A logical extension would be to consider R&D performed by universities to be market output as well. This decomposition could be made in several very different ways and different countries will sector higher education in alternate ways, based on differences in the way that universities are funded and operated in each country. The sectoring used in this paper is consistent the SNA language that identifies R&D as a non-market good based on its producer: "Research and development undertaken by

[4] The output would be from a sub-unit characterized as a quasi-corporation.
[5] For an analysis of this alternate treatment for U.S. colleges and universities, see Parker, Robert and Arnold Katz (1995); The Effects of Alternative Rules for Determining the Sectoral Classification of Colleges in the 1993 SNA: A Case Study for the United States.

government units, universities, non-profit research institutes, etc. is non-market production and is valued on the basis of the total costs incurred (CEC et al., (1994) par. 6.142)."

Federally Funded Research and Development Centers (FFRDCs) are owned by the U.S. federal government and administered under contracts between the U.S. government and institutions in industry, academia, and the non-profit sector. The sectoring proposal in these link tables moves FFRDCs to the general government sector.[6] This sectoring conforms to the interpretation of the SNA that implies that the SNA has characterized the R&D produced by government, education, and non-profits as a non-market good because it has more of the qualities of a public good than does the R&D produced by corporations and characterized as a market good. This non-market good may have positive or negative spillovers[7] that are not completely captured by the producer, or have greater inherent risks. Assuming that the government is funding the FFRDCs because the R&D conducted there has enough of this public goods quality to justify its cost, then the R&D can be characterized as a non-market good. In this case, the reasoning outlined above for sectoring the FFRDCs administered by private universities and non-profits can be followed. Industry-administered FFRDCs are government-owned, receive the vast majority of their funding from the government, and produce a non-market good. Using the SNA language about ownership and control of an institution that produces a non-market good, the industry-administered FFRDCs are sectored with the government.

[6] The NSF currently assigns R&D performed by FFRDCs with the sector of the institution that administers each FFRDC.

[7] Unregulated private sector R&D in infectious viruses and nuclear weapons, for example, may have negative spillovers.

In the tables that accompany this paper, the SNA-based general government sector is composed of R&D performed: 1) by the federal government by its agencies and labs; 2) R&D performed by public universities and colleges; 3) R&D performed by federally funded research and development centers; and 4) R&D performed by state and local governments.

2.3. The Private Non-profit Sector

The Frascati-based private non-profit sector is composed of non-market, private non-profit institutions and private households. It includes R&D activity conducted by both membership and philanthropic associations as well as the non-market R&D activity of households (OECD (2002) par. 194-197). The SNA-based sector includes private colleges and universities that Frascati has assigned to the Higher Education sector.

The SNA identifies the role of households as producers of goods and services in unincorporated market enterprises (CEC et al., (1994) par. 4.49-4.50). Household production is understood to be a very small component of R&D and the NSF surveys that count R&D do not allow this small component to be separately identified. In the Frascati Manual it is recommended that household production of R&D be divided between the business sector and the non-profit/households sector based on whether or not it is sold in the market. While no separate household sector is provided in this set of tables, R&D purchased by the Federal Government from individuals has been sectored with industry/corporations.

2.4. “Abroad” to Rest of the World

The Frascati-based expenditure data treat “Abroad” as a source of funds for R&D, and the Frascati Manual suggests a framework that could be used to break down

the flow of funds for R&D. This framework could subdivide "Abroad" into the following sectors: Business Enterprise, Other National Governments, Private non-profit, Higher Education, and International Organizations, and could further subdivide financial flows for R&D between multinational parent companies and their affiliates. A suggested geographic breakdown for the flow of funds for R&D between regions of the world would separately identify continents, OECD countries, non-OECD countries and major economic communities (OECD (2002) par. 231-232).

A SNA-based production framework calls for a complete accounting of international transactions in R&D services. Although survey data for the U.S. and many other countries do not provide the transactions necessary to fully measure this sector, improving these data would be one of the most useful aspects of the SNA-based treatment of R&D activity. While BEA data on trade in R&D services by multinational corporations are included in this analysis, the transactions reflected in these data are not currently completely separable from the R&D expenditure data. The Rest of the World sector in these tables begins to assemble the available data on imports and exports of R&D that would fill out the final uses of R&D services.

3. Translating Frascati Expenditures into Gross Output

In addition to assigning institutions to SNA-based sectors, several adjustments must be made to the Frascati-based expenditures to yield measures of gross output of R&D by sector. As described in Section 1, the SNA recommends estimating gross output for government and non-profits with total cost, and for own account R&D on the basis of the estimated base prices that would be paid if the research were subcontracted

commercially. While R&D services that are sold should be valued at basic prices, the Frascati data do not report prices. Instead, gross output must be added up based on costs. These should properly include the cost of any purchased R&D from either within or outside the sector as an intermediate input. Gross output also includes a charge for the amount of capital used up in production, but excludes capital expenditures, including those for software and equipment. It includes other taxes less subsidies on production, but not income taxes.

3.1. Starting with Frascati-based Expenditures by Performer

The basic measure of R&D performance in the Frascati framework is intramural expenditure by sector. These intramural expenditures are all expenditures for R&D performed within a statistical unit or sector of the economy during a specific period, whatever the source of funds. The Frascati Manual calls for separate expenditure data for current costs, with subcategories for labor costs of R&D personnel and for other current costs. Other current costs include materials, supplies, and non-capital purchases as well as costs associated with consultants who work on site and indirect labor costs. The Frascati Manual identifies three types of capital expenditures: 1) land and buildings; 2) instruments and equipment; and 3) computer software (OECD (2002) par. 376).

3.2. Ending with Gross Output in the SNA

National accounting provides three distinct ways to measure economic output. From the production side, GDP is equal to total output minus total intermediate consumption, plus other taxes less subsidies on products not included in the value of output. From the demand side, GDP is equal to final consumption expenditures plus gross capital formation plus net exports. From the income side, GDP is equal to the compensation of

employees plus taxes less subsidies on production and imports, plus gross mixed income plus gross operating surplus (CEC et al., (1994) par. 2.222).

The goal of the attached worksheets is to translate the Frascati R&D expenditures into gross output of R&D by building up the full costs of production. In translating the Frascati expenditures, this general expression shows the relationship of the components of the production account (CEC et al., (1994) par. 2.108): (Gross) Output = Intermediate Consumption + Consumption of Fixed Capital + Net Value Added. In current dollars, net value added is the sum of compensation of employees, other taxes on production and imports less subsidies, plus net operating surplus. Thus, if Frascati-based expenditures can be translated into these components or some combination of them, Frascati-based expenditures can be translated to SNA-based output for each sector.

The Frascati framework calls for separate reporting of current expenses from capital expenses. In practice, compensation costs of employees and some taxes on production are embedded with most intermediate inputs in the Frascati-based expenditure data. Subtracting compensation, which is in the expenditure data, from net value added leaves other taxes on production less subsidies and net operating surplus. Other taxes on production are those taxes that an enterprise incurs as a result of production, and specifically excludes taxes on profits or other income that are payable only when the firm is profitable (CEC et al., (1994) par. 7.70).

These two items, other taxes on production less subsidies and net operating surplus, together with consumption of fixed capital are needed to transform the Frascati expenditures into the basic components of gross output. Because of its importance in the value of output, an approximation of consumption of fixed capital is included in the

estimates. Capital expenses themselves are organized together in this Frascati-to-SNA link to develop an estimate of additions to capital formation.

Section 3.3 describes the steps involved in developing an SNA-based estimate of output from the Frascati expenditures. The gross output estimate is followed in each table by sections for gross additions to fixed capital formation and inventory investment and for exports and imports. While the translation of R&D expenditures themselves into stocks of useful intangible assets is the task of capitalizing R&D and is not addressed in this document, removing the additions to gross fixed investment is a necessary first step to prevent double-counting of R&D in a satellite account that capitalizes R&D. The value of R&D that would be ultimately be capitalized is gross output minus intermediate inputs.

3.3. Summary of the Frascati-to SNA Adjustments

This section describes the adjustments required to move from Frascati expenditures to SNA-based gross output. The adjustments are summarized in Table B below. The application of these adjustments to actual source data as compiled by the NSF for the U.S. submission to the OECD is described in the section of the paper that follows and detailed in the worksheets that accompany this paper.

Table B. Frascati to SNA Adjustments

		Explanation of Adjustment
I. Output		
Frascati-Based Output, Gross Domestic Expenditures on R&D (GERD)		
Plus expenditures for R&D as defined by SNA but excluded from Frascati-defined R&D	+/-	The scope of R&D in the SNA is not clearly defined and can be interpreted differently from that of the Frascati Manual. The SNA could be interpreted to include spending that leads to new or improved products or processes without explicit novelty. It can also be interpreted to exclude basic research that is not directed toward product or process improvement.
Plus R&D purchased as an intermediate input to production of R&D in the sector	+	SNA-based gross output includes intermediate consumption, including the cost of any purchased R&D. Frascati-based output is reported either by performer or by funder and excludes intermediate consumption to avoid double-counting.
Plus any drawing down of inventories or supplies	+	SNA-based gross output reflects the value of inputs used in the production process, while the Frascati-based measure includes all expenditures for R&D. This is likely a small amount, no adjustment is recommended.
Remove any additions to gross capital		
Subtract capital expenditures for structures, equipment, and software	-	Frascati-based reporting calls for separate accounting for capital expenditures, these are land and buildings, equipment and software. All of these expenditures should be removed from an SNA-based measure of gross output.
Subtract costs for own account software developed for internal use	-	Costs for developing own-account software are included in labor costs in Frascati-expenditures, and should be subtracted because software used in the production of R&D is a capital input.
Subtract additions to inventories or supplies	-	Expenditures for materials and supplies not used for R&D production in the current period are not part of the value of output.
Adjustments to move from expenditures to full value of output		
Plus consumption of fixed capital on structures, equipment, and software owned by R&D producers and used to perform R&D performed in the US.	+	The SNA includes consumption of fixed capital as part of the cost of production, Frascati-based expenditures do not include depreciation or CFC measures.
Plus other taxes on production less subsidies	+	Some taxes on labor are included in Frascati-based expenditures, others may be missing.

Plus Net Operating Surplus	+	The return on capital includes both consumption of fixed capital and the net operating surplus or markup. No net operating surplus is included in the estimates of output for non-market production.
Gross Output		

Table B continued, Frascati to SNA Adjustments

II. Exports and Imports of R&D Output	
Exports	+
Imports	-
Net Exports	

III. 'Gross Capital Formation	
Fixed Investment	
Investment in structures	+
Investment in Equipment	+
Investment in Software	+
Net disposals of capital goods	-
Fixed Investment Subtotal	
Investment in inventories	+
Gross Capital Formation	

3.3.1. **The scope of R&D**

While the translation tables that accompany this paper assume that the Frascati-based scope of R&D activities matches the SNA's scope, the absence of a clear SNA definition of R&D allows for it to be interpreted both more narrowly than Frascati-based R&D and more broadly. A narrower interpretation would exclude activities that do not lead to improved products or production processes, removing some basic R&D expenditures (Mandler and Peleg (2003b)). One area where the SNA-based expenditure concept is clearly narrower than the corresponding Frascati measure involves research conducted by students at the PhD level. Frascati-based R&D expenditures should include scholarships and stipends for research conducted by the PhD students (OECD (2002)

par. 68, 324) while R&D on an SNA basis would only include this activity when the expenditure took the form of employee compensation.[8]

SNA language on activity improving efficiency or productivity (CEC et al., (1994) par. 6.163) does not limit the scope of R&D to purely novel, uncertainty resolving, or potentially patentable activities. This distinction is noted in a recent paper by Baldwin, Beckstead, and Gellatly (2004) of Statistics Canada, addressing Canada's expenditures on knowledge capital in general. They suggest that the Frascati definition of R&D may underestimate the appropriate SNA-based measure of R&D. The broader interpretation of R&D would disproportionately impact R&D undertaken within the service industries. For these industries efficiency improvements are frequently developed in the supply chain, system operation, and expert systems (Jankowski (2002) and (Brown et al (2004) page 57). Keeping these alternate interpretations in mind, the scope of Frascati-based expenditures is assumed to be a reasonable match for the intent of the SNA, and no adjustment is recommended.

3.3.2. R&D acquired as an Intermediate Input

Estimating gross output includes valuing the costs of all intermediate inputs, including R&D purchased from others that is used in the production of R&D. However, since Frascati-based expenditures report R&D by performer, double-counting of R&D is avoided but intermediate purchases of R&D are not fully captured. On an SNA basis intermediate inputs are identified by establishment (CEC et al., (1994) par. 2.137) and all intermediate inputs should be included in estimates of gross output. Thus a separate entry is provided in the translation tables for the acquisition of R&D used as an intermediate

[8] In practice, the U.S. academic survey data reflects only wages and salaries and excludes fellowships and scholarships. Thus the distinction is a moot point in the data translation.

input, whether this acquisition is from within the sector or outside the sector.[9] Since this acquisition represents a purchase of R&D, it should be recorded at market price, which includes operating surplus, rather than at cost of production. While this treatment results in counting R&D as output for the unit that sold it as well as for the unit that purchased it as an intermediate input in the production of the purchaser's R&D, these intermediate inputs would be subtracted out in a final measure of the value-added associated with R&D activity.

For market producers of R&D, the economic concept of intermediate R&D inputs is clear and can be identified as the purchase of R&D services. For nonmarket producers, the transaction that should be identified is the acquisition of R&D services that are used in the further production of R&D by the nonmarket producer. This identification is hampered by role of government and non-profit institutions in funding the performance of R&D by other institutions under a variety of contractual arrangements. The economic transactions that occur when the federal government funds R&D performed by others should ideally be identified so that grants, subsidies and transfers can be separated from intermediate purchases.

3.3.3. Materials and Supplies

Inventoried materials and supplies are not separately accounted for in the Frascati framework since Frascati counts purchases instead of consumption of intermediate goods. An SNA-based measure would count materials and supplies consumed as intermediate consumption and any materials and supplies carried over from

[9] Since a final accounting of R&D output should be presented net of acquisitions, Mandler and Peleg suggest this special treatment of acquisitions may prove useful for the final purpose of capitalizing R&D and allocating this capitalized asset to the sector or industry that owns it (Mandler and Peleg 2003(a)). Two effects are then captured by this treatment of intermediate inputs—the R&D services end up in the sector that purchased them and, in this case, they are valued at purchasers prices.

one year to the next would be inventory investment. This treatment is applied in the link tables. Inventory investment is a category of capital investment separate from gross fixed investment and the drawing down of inventory is a cost of current production.

3.3.4. **Separate Additions to Fixed Capital from Gross Output**

An SNA-based measure separates current expenses from capital formation because the latter produces a flow of services that is not completely consumed in the current period. In the SNA, a produced capital asset is one that is used repeatedly, or continuously, in processes of production for more than one year (CEC et al., (1994) par. 10.7). Since these additions to capital are properly measured as changes to gross fixed investment, any existing capital expenditures embedded in the Frascati-based expenditure data must be removed to prevent double-counting.

In addition to structures and equipment (but not land),the SNA recognizes software that is expected to be used in production for more than one year as an intangible, produced fixed asset (CEC, 1994, par. 10.92). This includes the cost of prepackaged software, custom software, and own account software as well as the cost of development of large databases that are expected to be used in production for more than one year (CEC, 1994, par. 10.93). The Frascati Manual provides for a classification of capital costs that are subdivided into: land and buildings; instruments and equipment; and computer software ((OECD (2002) par. 376).

R&D expenditures that are used to create own-account software are not included in the capital costs described above (OECD (2002) par. 383) and will be counted as Frascati-based expenditures when they depend on a technical or scientific advance, and resolve a scientific or technical uncertainty. Since this expenditure creates an intangible

fixed asset that is counted as investment based on the cost of developing it, the expenditures must also be removed from current R&D output to avoid double-counting. However, these link tables include in the measure of R&D gross output the cost of developing software for sale, a cost that is specifically excluded from R&D expenditures by ESA 1995.[10] When the BEA capitalizes R&D in its satellite accounts, these software development expenditures need to be removed to prevent double-counting since both the software created and the R&D would be capital assets.[11]

3.3.5. Adjustments to move from expenditures to full value of output

This cost estimation method should represent the full costs of production, which from the production side equals intermediate inputs plus gross value added. The costs within gross value added that are not accounted for in Frascati-expenditures are non-labor taxes and subsidies on production, consumption of fixed capital and net operating surplus. In the SNA, this consumption of fixed capital (CFC) is the decline in the value of the fixed assets value of the fixed assets owned by an enterprise, as a result of their physical deterioration and normal rates of obsolescence and accidental damage. The value of a fixed asset is determined by the benefits that can be expected to flow from the asset for the remainder of its service life. This value is estimated in current period prices as a discounted value that would accrue to the owner of the fixed asset if it were to be

[10] The ESA 1995 calls for the exclusion of all software development costs from R&D expenditures: "**Expenditure on R&D does not include the costs of developing software as a principal or secondary activity.** However, their accounting treatment is nearly the same; the only difference is that software is regarded as a produced intangible asset and is not patented. (Eurostat (1996), par. 3.64)."

[11] The SNA currently recognizes two distinct products embodied in the creation of a software original, the software original itself and the copies that can be made from the original. The value of the software original, which may be protected by copyright, is determined by the receipts or sales of the copies of the original and must cover the production costs of both the original and the copies (CEC, 1994, 6.143). Mandler and Peleg (2003) note that the capitalization of R&D could result in three distinct products from the use of R&D to develop a new computer language that is used to develop a software original. First, the research that may be used to develop new kinds of software, second, the software original, and third, the copies that are mass produced. If R&D were capitalized, two assets have been produced, the R&D developing the new language, and the software original.

rented out at current prices for the remainder of its service life (CEC, (1994) par. 10.118). Since the Frascati framework provides for capital expenditures in total expenditures, it does not include a measure of the consumption of existing fixed capital as part of current expenses.

The SNA recommends different approaches to valuing output for R&D for market producers and for non-market producers. Market production of R&D includes R&D produced for sale and own account R&D. R&D that is produced for sale, for example, the output of NAICS industry 5417, R&D Services, should be valued at basic prices. While own account R&D should also be valued at estimated basic prices, the SNA suggests that production costs may need to be used instead when reliable market prices are not available. This "second best procedure" is to value output of the goods or services produced for own account as the sum of their costs in production, specifically intermediate consumption plus compensation of employees plus consumption of fixed capital plus other taxes less subsidies on production (CEC et al., (1994) par. 6.86).

In practice, estimated basic prices can differ from those constructed using the "second best procedure" of summing the costs of production. This difference involves the taxes less subsidies on production. Since the basic price is "the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any tax payable, and plus any subsidy receivable, on that unit as a consequence of its production or sale (CEC et al., (1994) par. 6.205)," it reflects the social or full cost of production. Using the SNA's second best procedure to value own account output, the calculation calls for the addition of other taxes and subtraction of subsidies on production. This latter calculation produces an estimate of the private cost of production

rather than the social cost. The approach to this problem taken by Mandler and Peleg (2003b) is to consider these subsidies as components of R&D funding rather than performance.

Using this second best procedure, no estimate would be made for net operating surplus. Net operating surplus is value added minus compensation of employees, minus taxes on production, plus subsidies, minus consumption of fixed capital (CEC et al., (1994) par. 7.80). Charges that are deducted from this net operating surplus include explicit or implicit interest charges and rents or other property incomes payable on financial assets, land or other tangible non-produced assets required to carry on production ((1994) par. 7.82). The general valuation rules of the SNA call for market and own-account goods and services to include a mark-up that reflects the net operating surplus or mixed income attributable to the producer (CEC et al., (1994) par. 3.73).

While the second best procedure described above includes no estimate for net operating surplus, its exclusion underestimates full cost. The mark-up or net operating surplus provides for interest payments as well as payments for rent on land and other non-produced tangible assets ((CEC et al., (1994) par. 6.178). Since this surplus is measured as a residual, it is noted in the tables without an associated estimate. However, for non-market output, the SNA specifically excludes any net operating surplus (CEC et al., (1994) par. 6.91).

3.3.6. **Imports and Exports and Gross Additions to Capital Formation**

While the Frascati Manual provides a framework for international flows of R&D, in practice the Frascati-based expenditure data do not generally provide the information necessary to create complete estimates of either imports and exports or of gross additions

to capital formation. These two sections of the table are provided to describe a possible layout for this information. The SNA-based rest of the world sector consists of non-resident institutional units that enter into transactions with resident units. The rest of the world sector includes institutional units with the domestic country's boundaries when they are entities like foreign embassies, consulates or military bases or international organizations (CEC et al., (1994) par. 4.163). Exports are considered to be sales, barter, gifts or grants of goods and services from resident to non-resident units (CEC et al., (1994) par. 14.88).

The Frascati framework includes the Abroad sector as source of R&D funding and as destination of R&D resources. Abroad consists of 1) institutions and individuals located outside of the political boundaries of a country[12] and 2) international organizations other than business enterprises, including those international organizations that exist within a country's borders (OECD (2002) par. 229). The transactions to and from abroad are included in the extramural expenditures reported by R&D performers, but are not generally separately identified in the Frascati-based data in practice. This means, for example, that R&D performed in the US and sold as an export of R&D services to a nonresident unit would be counted in the R&D expenditure data as well as in the Export data in the link tables.

Accounting for the full cost of production involves creating a framework for measuring the stocks of capital that provide a flow of services to produce R&D. The final section of each table presents the changes in gross investment for the sector. These changes are composed of investments in structures, equipment, software, and changes in

[12] The testing and operation of vehicles, ships, aircraft and space satellites, as well as the testing grounds of a domestic institution is not considered as "Abroad" (OECD 2002 par. 229).

inventories minus the sale of any used assets. A further potential for double-counting capital involves the disposals or resale of capital assets. Within the SNA framework, gross fixed capital investment is reduced by these sales and disposals. A full measure of value would also reflect changes in the value of assets due to holding losses and revaluation, an adjustment that is not included in the link tables.

The Frascati-based measures include expenditures for land along with capital expenditures. For the SNA, land is considered to be a tangible non-produced asset, and only improvements to land would be included in gross fixed capital formation (CEC et al., (1994) par. 10.51). However, the SNA recognizes the difficulty in separately valuing existing land and structures, and in this case suggests that a transaction involving an existing structure be classified based on the asset with the higher value—either the land or the structure. In the case where this determination cannot be made, the SNA suggests that the transaction be classified as the purchase of a structure (CEC et al., (1994) par. 10.125).

Summary Table B of the Link Tables reconciles Frascati-based expenditures for 2001 with the translation to gross output. With the data currently available, the translation adds about 15 billion dollars to expenditures. The columns in Row I are the initial Frascati-based expenditures rearranged into SNA sectors. The Row I total in the far right column of Table B is the Frascati-based U.S. expenditure for R&D that comes from the NSF's U.S. data submission.[13] Table B indicates that the adjustments to align the scope of the U.S. survey data with that of the Frascati/SNA framework adds about 1

[13] The NSF submission to the OECD is not entirely consistent with the standards of the Frascati Manual. Further discussion of the differences are discussed in Section 4 .

billion dollars. Intermediate inputs add about 3.3 billion dollars.[14] Basic adjustments for embedded capital expenditures removes about 3.1 billion; with the exception of the federal government, this does not include any adjustment for embedded software. The largest adjustment comes from the addition of an estimate for consumption of fixed capital, an addition of 13.3 billion in Row V.[15] A small adjustment of 647 million dollars represents R&D performed by state and local governments.

4. Description of Sector by Sector Concordance Issues

The worksheets that accompany this text are based on US source data from the NSF for R&D expenditures. The translation tables from each data source have three parts. Part 1 provides a translation of Frascati expenditures to gross domestic output for each sector. Part 2 describes R&D transactions between resident and non-resident units in terms of imports and exports. Part 3 of each worksheet breaks out the changes in gross fixed capital and inventory. The starting place for each sector's estimate is the Frascati-based expenditure for the performance of R&D in calendar year 2001. In each case where survey data are available for the adjustment, the adjustment amount is provided in this column. Missing components that are very large or necessary for the CFC imputation are estimated.

4.1. National Science Foundation Survey Data

The National Science Foundation's Division of Science Resources Statistics coordinates the collection and reporting of survey data on R&D expenditures and consolidates these data in the publication, National Patterns of Research and Development Resources (NSF 2003a). These surveys provide the basis for the U.S.

[14] This value will rise as disaggregated data from the NSF for industrial R&D becomes available.
[15] This value will shrink once the historical cost depreciation for industrial R&D is subtracted.

component of the OECD data on expenditures by performers and expenditures by funders. Two annual surveys published by the NSF provide direct information on R&D expenditures. These are the Survey of Industrial R&D (SIRD or RD-1) and the Survey of Research and Development Expenditures at Universities and Colleges (NSF 411). An abbreviated version of the NSF 411 survey is collected annually for federally funded research and development centers. Two additional annual surveys provide information on outlays and obligations by the federal government for R&D. These are the Survey of Federal Funds for R&D and the Survey of Federal Science and Engineering Support to Universities, Colleges, and Nonprofit Institutions. The Scientific and Engineering Research Facilities Survey is conducted biennially. An NSF sponsored Gallop survey, Research and Development Funding and Performance by Nonprofit Organizations was last conducted in fiscal 1996 and 1997 and has been discontinued. The Survey of State Research and Development expenditures was conducted in 1988 and 1995.

The translation tables accompanying this paper are laid out to illustrate the use of the survey data to account for R&D on an SNA basis, and the tables indicate where no survey data are available for the estimate. Where non-survey based approximations are used, they are indicated in italic font in the tables. The NSF-collected data that form the US submission to the OECD for the Frascati-based R&D expenditures are not disaggregated into the Frascati recommended subcategories of labor costs, other current costs, and capital breakdown of structures, equipment and software. For the industrial, academic, and non-profit surveys, capital expenditures are explicitly excluded and a historical cost deprecation measure is included as part of indirect cost.

Because of the importance of consumption of fixed capital (CFC) in estimating full value, approximations are made for both investment and CFC. First, an estimate is made of capital investment for sector. Capital investment for R&D in each sector for 1) equipment and software and 2) for structures is assumed to be made in the same ratio to gross output as in the R&D services industry, NAICS 5417. These two ratios, equipment and software to output and structures to output, are created from the 1997 BEA capital flow table and the 1997 BEA benchmark Input-Output table. The ratio of CFC to investment is calculated for 2001 for equipment and software and for nonresidential investment from NIPA investment data. This is done for private investment and applied to market R&D and for general government and applied to nonmarket R&D.

4.2. Business Sector

The Frascati-based measure, Business Expenditures for R&D, is the sum of industry performed R&D and R&D performed at industry-administered federally funded research and development centers (FFRDCs). Since FFRDCs are included in the government sector in the SNA-linked tables, the starting point for the business sector expenditure total is the Frascati-based total minus expenditures at FFRDCs. The tables accompanying this paper link the Frascati-based business sector to two SNA-based sectors; these are nonfinancial corporations (Table 1) and financial corporations (Table 2).

The source data for Industry R&D come from the Survey of Industry Research and Development (the RD-1 survey) a Census administered, company-based survey whose target universe is all for-profit, nonfarm[16] industrial companies that perform R&D.

[16] On a NAICS basis, farm industries are the three-digit industries 111, Crop Production, and 112, Animal Production. Crop production establishments primarily grow crops, plants, vines, trees, and their seeds. Animal production establishments raise or fatten animals for the sale of animals or animal products (Executive Office of the President, 2002).

Industrial classification for a company is based on the industry classification of the activity within the company with the highest dollar value of payroll (NSF (2003b) pg. 121). While the published data from the NSF do not provide a breakdown between financial and non-financial corporations, since the underlying data are coded by NAICS industries, the financial corporations can be separated out and aggregated. The Financial sector is identified by those enterprises whose principle activity is classified in International Standard Industrial Classification of all Economic Activities (ISIC) divisions 65, 66, and 67 (CEC et al., (1994) par. 4.79). The NAICs industries included in this sector are listed in the Appendix.

Two adjustments follow that reflect the gap between survey coverage of enterprises and the theoretical SNA measure, rather than the gap between the Frascati-values and the SNA measure. The first is for survey coverage of the scope of reported R&D. On a Frascati basis, it should cover R&D in the social sciences and humanities (OECD (2002) par. 222). The RD-1 survey collects data on R&D in fields of science and engineering but not for social science and humanities.[17]

While the RD-1 survey also excludes the R&D expenditures at firms classified by NAICs in the agricultural sector, the magnitude is believed to be very small. An analysis of the Census microdata[18] found that agribusiness firms performing R&D tend to be classified in the food, beverage, and chemical manufacturing industries rather than in Agriculture. While the current magnitude of the missed expenditures is unknown, the

[17] The NSF provides two reasons for this coverage; first, they argue that the respondents inexperience with these data would render the data not comparable with that collected in other sectors. Second, the NSF argues that industry-performed R&D in the social sciences is focused primarily on firm internal decision making about existing processes and products and is not focused on new products and processes (NSF 2001a).

[18] As described by Brandon Shackelford of the NSF.

total reported in the NSF's survey of industrial R&D for agricultural services in 1997 was $7 million dollars, or about .0045% of industry-performed R&D for that year (NSF (2000)). For these reasons, no adjustment for agriculture is recommended.

Next, the R&D expenditures of non-profit institutions that serve the business sector are added. In both a Frascati and an SNA framework, these expenditures should be included in the business sector. These types of non-profits were identified as trade associations and industry consortiums on the last NSF sponsored Gallop survey, Research and Development Funding and Performance by Nonprofit Organizations. The largest of these performers in 1997, the last fiscal year with individual data, is SEMATECH, Inc., a consortium of semiconductor manufacturers, with expenditures of $97 million in 1997 (NSF (2001b), Table A-11). While ideally these institutions should be assigned to either the financial or non-financial sector, depending on the sector of the businesses whose interests they are designed to promote, in this link they are assigned to the non-financial corporations sector.

The adjustment for R&D used as an intermediate input to production of other R&D can be made based on a survey question about purchased R&D on the RD-1 survey. This question specifically asks for the cost of R&D performed by others for the company, and divides it into for profit companies, universities or colleges, and other non-profit organizations. It excludes R&D performed for the company outside of the U.S.

An adjustment to the Frascati-based expenditures for the Business Sector separates current expenditures from embedded capital expenditures.[19] To the extent that research equipment and software purchases are included in the Frascati-based current

[19] Conceptually, the capital expenditures to be removed are those identified on an SNA-basis, as described in Section 3.3.4.

expenditures, they should be removed and reassigned to capital expenditures. Determining the extent of software spending in the Frascati-based numbers poses a substantial challenge. Instructions for the RD-1 form tell reporters to include the cost of computer software used in R&D activities and exclude capital expenditures (NSF and U.S. Department of Commerce (2002)). While the RD-1 form does identify expenditures for the creation of software produced for sale to others, neither the RD-1 or other NSF surveys identify the expenditures for the purchase and creation of software (own account) used in production.[20]

Since the RD-1 form tells respondents to exclude capital expenditures, firms that capitalize or amortize their expenditures on software for tax purposes can reasonably be assumed to have excluded these expenditures from their reported R&D performed. However, the share of total business purchase of software that is capitalized for tax purposes is currently not known with any certainty.[21] The current BEA methodology assumes that only a small percentage of software actually is capitalized in Internal Revenue Service (IRS) returns. According to David Wasshausen of the BEA, the BEA currently assumes that 80% of prepackaged and custom software are not reported as

[20] The R&D costs for software created and sold to others would be excluded from R&D activity in a satellite account that capitalizes R&D to avoid double-counting.

[21] Both accounting standards and tax regulations provide room for firms to either expense or capitalize the software expenditures associated with R&D activities, depending on the future use of the software. Accounting standards call for software with a useful life of more than a year to be capitalized. With respect to intangibles (software) purchased to be used in R&D activities, accounting standards call for expensing those without future uses and amortizing those with alternate future uses (FASB (1974) par 11). This directive is interpreted to include software created inhouse FASB (1975 par 6 – 8). The costs of developing software for sale are considered R&D expenses until technical feasibility is determined, which involves the development of a working model. Thereafter development costs are to be capitalized (FASB (1985) par 3). According to the IRS, purchases of software and creation of own account software can be treated either as capital investment or as a current expense, as long as the firm's treatment of software is consistent. (IRS (2000)) as modified by Revenue Procedure 2004-11, Internal Revenue Bulletin 2004-3, January 20, 2004.

Since the IRS permits items that would otherwise be capitalized but have a value under a certain threshold to be expensed, Grimm, et. al (2003) suggest that a large share of software falls below this threshold and is expensed.

investment to the IRS, and that 97% of own-account software is not reported to the IRS as investment.[22] In its accounting of consumption of fixed capital for software, the BEA adjusts IRS-reported depreciation of software to account for this underreporting. To get an idea of the size of the adjustment made by the BEA for the NIPA-based corporate sector, IRS reported depreciation and amortization was $761.8 billion in 2001, and the BEA added $113.9 billion for depreciation of software not reported in the IRS numbers. Because of the uncertainty surrounding the magnitude of these embedded costs, no subtraction of these embedded software costs is currently included in the translation tables.

Three further adjustments are needed to reflect the value of gross output. First, the consumption of fixed capital is a production cost that must be accounted for in an SNA-based accounting of output. Since the RD-1 form includes an estimate of depreciation at historical cost, this estimate could be adjusted to current costs. Until these data are available, the estimates displayed in tables 1 and 2 are approximated from BEA data from the Input Output Tables, the Capital flow tables and NIPA data using the procedure described in Section 4.1.

Any unreported other taxes on production less subsidies must be added to the expenditure for the full value of output. The RD-1 data contain taxes paid on labor as well as property taxes. While the RD-1 survey specifically excludes the value of tax credits and does not consider subsidies, no missing production subsidies have been

[22] However, he notes that these estimates are not based on any hard numbers. In April of 2005 results from the Census's Information and Communication Technology supplement to the Annual Capital Expenditures Survey (ACES) will be released, providing more information on capitalized and expensed software.

identified.[23] A final adjustment for full cost of production involves the addition of a net operating surplus for market producers. As discussed earlier, the SNA method for valuing the output of own account production does not include a net operating surplus, though it would be contained in basic prices. Interest charges and payments for rent of land are paid out of net operating surplus. Since the RD-1 survey excludes costs for interest, the exclusion of an operating surplus will, in effect, somewhat undercount the full costs of production.

The accounting of exports and imports in Section II of the nonfinancial corporate sector table is based on BEA data on trade in R&D services for affiliated and non-affiliated US corporations. For trade between multinationals and their affiliates the share of trade in R&D services attributed to firms in the financial sector is negligible. The survey data do not allow the unaffiliated trade data to be disaggregated by industry. These trade flows cannot be separated, however, from the Frascati-based expenditures since the Frascati performer based data can include R&D that was an exported service.

Section III of the tables for the financial and non-financial corporations sectors provides a framework to account for additions to gross fixed investment. While the RD-1 data do not provide information on capital expenditures, a rough estimate was made in order to create a proxy for consumption of fixed investment. These were created based on the ratio of investment to gross output for NAICS industry 5417, R&D services.

[23] While the US federal tax code provides an R&D tax credit to firms with a 2001 value of $6,353 million, this tax credit is considered an adjustment to income taxes rather than a production subsidy. This is because they are only payable when the firm is profitable and thus has a tax liability, instead of being payable solely as consequence of production. Corporate income taxes are paid out of the net operating surplus but are not a cost of production. For a SNA discussion on other taxes on production, see CEC et al., (1994) par. 7.70. The characterization of tax credits as an adjustment to income taxes is not directly addressed in the SNA and follows current BEA interpretation.

4.3. Government

The government sector is composed of the R&D performed by 1) agencies of the federal government, 2) Federally Funded Research and Development Centers, 3) publicly owned colleges and universities, and 4) state and local governments. Tables 4 through 7 detail the links for each of these four subcomponents, and Table 3 aggregates them. While annual NSF survey data are available based on performance for the agencies of the federal government, for colleges and universities, as well as for FFRDCs, the data for FFRDCs are currently limited in the detail provided. There is currently no annual NSF survey for R&D performed by state and local governments.

4.3.1. Federal Government Performed R&D

U. S. federal government performed R&D is reported on a Frascati basis as GOVERD, or government expenditures on R&D. These expenditures are subdivided into labor costs, other current costs and total capital expenditures. The Frascati-based numbers differ from those reported in NSF's Table B1 of National Patterns of R&D Expenditures (NSF 2003a) in that the National Patterns numbers do not include a capital expenditure measure. This capital expenditure sum comes from a transformation of reported obligations based on fiscal years into performance.

The NSF's annual Survey of Federal Funds for R&D provides information on obligations and outlays of the federal government for R&D for fiscal years, which run from October 1 to September 30. Obligations are orders placed, contracts awarded, services rendered and similar transactions. Outlays are the actual checks and cash payments made during a given period (NSF (2004)). These costs are reported as full coverage, which includes planning, administration, and overhead. The survey data do not

provide a means to identify intermediate purchases of R&D. These are estimated using federally funded performance of R&D in industry 5417 from NSF's Science and Engineering Indicators (NSF (2004a), which are derived from its RD-1 survey. Its use assumes that all of the federally funded performance in this industry is an intermediate input into the government's production of R&D, rather than a transfer or grant for R&D performance.

Data are reported for R&D plant, which includes R&D facilities and fixed equipment. This includes land but excludes mobile equipment, and thus is not a complete measure of SNA based capital assets. To transform these expenditures from a Frascati basis to a SNA basis, capital expenditures must be first subtracted from current expenditures. While the totals for R&D plant and fixed equipment can be readily backed out of obligations data, adjustments need to be made for other capital, like test equipment in the laboratory, office furniture, computers, and software. No survey data are available to estimate the amount of current expenditures that are devoted to this test equipment and software. Unlike uncertainty surrounding the extent of software expenditures embedded in the RD-1 data, there is little doubt that the federal performance numbers include this type of capital. The estimate used in the translation tables is based on equipment and software for NAICS 5417.

In order to estimate CFC, a proxy for investment in equipment and software investment is created together with the CFC estimate. An estimate for equipment and software investment is made assuming the same investment to gross output ratio as in the R&D services industry as described in Section 4.1. For the survey-reported expenditures

on plant and equipment, the CFC ratio to investment for general government nonresidential structures is used.

Since government–performed R&D is considered non-market output by definition in this set of translations tables, no adjustment is needed for net operating surplus. As noted earlier, this may undervalue output since interest and some rents are paid out of net operating surplus.

Section II of the table reports exports and imports. In the absence of better measures of imports and exports of R&D services, obligations for foreign performers are used for imports of R&D services for the Federal Government. This measure excludes payments made directly by US government agencies, organizations or citizens performing R&D abroad for the Federal Government (NSF (2004b), Technical Notes page 8), which leads to an undercount of imports of currently unknown magnitude for this component.

4.3.2. Federally Funded Research and Development Centers

These facilities are owned by the federal government and operated for the government by existing outside institutions or by non-profits that have been created for the purpose of administering the centers. While the NSF in its reports to the OECD assigns these FFRDCs to the sectors that contain the institutions that administer them (business, higher education, and non-profit institutions), an SNA-based sectoring properly assigns them all to the government sector based on two considerations. First, the type of R&D performed there is non-market, and second, the federal government both finances and controls these centers, thus they belong in the government sector. The

expenditures for these centers are estimated in Table 5, then aggregated with components of government R&D in Table 3.

The U.S. source data since fiscal year 2001 for the FFRDCs come from an abbreviated version of the NSF's academic R&D survey. This form provides very little detail for the adjustments necessary for the Frascati-to-SNA link. The adjustments for which there are insufficient survey data are the adjustment for acquired intermediate R&D, the adjustments for purchased and own-account software and any research equipment embedded in current expenditures. An adjustment for consumption of fixed capital is necessary even though the indirect costs asked for on the survey form conceptually include depreciation. This is because the latter is historical cost based rather than current cost based.

Accounting for imports for the FFRDCs involves identifying expenditures that are either made outside of the US or are payment for services provided by vendors based outside the U.S. Accounting for exports involves adding expenditures for R&D at FFRDCs that are funded by sources outside of the U.S. The NSF 411 form does not provide an entry to separately identify foreign sources of funding, though it does have an entry for "all other" after articulating government, industry, and institutionally financed research. Foreign funding would be a component of this.[24]

Finally, limited information is available to create an accumulation account for gross capital formation for the FFRDCs. Of the five components of gross capital formation, structures, equipment, software, inventories, and net disposals of capital

[24] One FFRDC that this is particularly relevant for is the Aerospace Corporation, because federal funds accounted for only 32% of its funding in 2001 (NSF 2003a) and the center performs work for international organizations, and other governments when such work is deemed to be in the national interest. In terms of payments to foreigners, the National Astronomy and Ionosphere Center is located in Arecibo Puerto Rico and expenditures there should be counted as payments to non-resident institutions.

goods, the first three components would be most important to capture. The federal funds data provide obligations for R&D plant that are used in the table for fiscal years 2000 and 2001 to create a calendar year estimate for 2001. Equipment and software are estimated based on BEA measures.

4.3.3. **Publicly owned colleges and universities**

Table 6 translates the Frascati-based expenditures for U.S. Higher Education R&D (HERD) into a public education component of the general government sector. The expenditure data are based on the NSF's Survey of Research and Development Expenditures at Universities and Colleges and are reported for current expenses, including indirect costs. The translation procedure in this table is repeated in Table 10, where the remainder of Frascati-based HERD is translated into a private education component of the non-profit sector.

In this division of the Frascati-based higher education sector, publicly-owned colleges and universities are assigned to the government sector based on a tabulation of the source data from the Survey of Research and Development Expenditures at Universities and Colleges. University expenditure data have been adjusted by the NSF to remove passthroughs of funds from the university to other performers. Expenditures for FFRDCs administered by universities and colleges are subtracted out. While they are included in the OECD's Frascati-based expenditures for Higher Education, expenditures for FFRDCs are assigned to the general government sector in this link and presented separately in Table 5.

Frascati-based R&D expenditures should include scholarships and stipends for research conducted by the PhD students (OECD (2002) par. 68, 324) and the

corresponding measure of R&D on an SNA basis would only include this activity when the expenditure took the form of employee compensation. However, because the U.S. academic survey data reflect only wages and salaries, no adjustment is needed to remove expenditures for scholarships and fellowships.

The NSF survey does not identify the purchases of R&D services needed to construct a measure of intermediate inputs of R&D, and these are considered to be very small by the NSF survey staff. Passthroughs are grants or transfers rather than the purchase of intermediate inputs of R&D and specifically exclude contracts for purchased services.

Identifying embedded capital expenditures again poses a challenge. There is no survey question identifying these costs, and as was the case with corporate accounting, these costs may or may not be capitalized and therefore excluded from current costs. While the SNA identifies assets with a useful life of greater than a year as a capital asset, for academic accounting this standard may be applied as well as a threshold value for capitalization that varies from $500 to $10,000.[25] For public colleges and universities, expenditures on research equipment for science and engineering were reported at $1,088 million for 2001, this value is subtracted in Table 6. Any embedded costs for purchased software and own-account software should also be subtracted. Because of the uncertainty surrounding the magnitude of these embedded costs, no estimate of these embedded software costs is currently included in the translation tables.

Since the academic form includes indirect costs, which are assumed to include depreciation, the historic cost measure of depreciation embedded in these performance

[25] GASB 35, Depreciation and Infrastructure Requirements, indicate that equipment purchases over $5,000 must be capitalized and depreciated, as well as some purchased or developed software with costs over $1,000,000.

expenditures is subtracted based on estimates from 1997 survey data. The adjustment for consumption of fixed capital is made based on BEA estimates of investment and depreciation as described earlier, using the investment ratios to output of NAICS 5417 and the CFC rates from general government from the NIPAs. Since the R&D output of the government sector and the non-profit sector is considered non-market output in this analysis, the SNA calls for a zero net operating surplus.

Section II accounts for R&D transactions between academic institutions and non-resident units, but no information for identifying purchases or sales to foreign entities is available on the academic R&D form. Section III categorizes gross fixed investment. The values for investment in structures ($187 million) and in equipment and software ($1,146 million) are BEA estimates. Although some data are available from the NSF surveys for capital investment, the BEA estimates were used because the available survey data for 2001 did not fully match the investment categories. The BEA estimate for equipment and software is similar to the available survey data for equipment ($1,088 million), however, only software embedded in research equipment is included in this measure. The BEA estimate cannot be compared well to the facilities survey data, which describes planned construction projects biennially, rather than actual expenditures.[26] In addition to questions about the square feet of space devoted to science and engineering research, this survey also contained construction, repair, and renovation spending questions up to and including 1998. In 2001 these expenditure questions were dropped but were replaced in the 2003 survey. The most useful information for developing

[26] The 1998 survey provides data on total project costs for construction projects for science and engineering research facilities that begin in either 1998 or 1999 for public institutions and for private institutions. For public institutions the total for the two years for project cost is $1,810.1 million and for private institutions the total for the two years is $955.3. The source for these totals is Table 25 and Table 26 of NSF (2004c).

estimates of R&D capital stock would ask respondents for annual capital expenditures for structures, equipment, and software, but this has been described as some of the most burdensome information for respondents to provide.[27]

4.3.4. State and Local Government

This section describes the NSF data available on the performance of R&D by state and local governments that is conducted separately from that performed in public universities. Since most public universities are state institutions, that component of government-performed R&D activity is captured in the academic R&D performance data and reflected in Table 6. While no annual survey exists for the performance of R&D by state agencies, state surveys have been conducted for the NSF periodically using a framework comparable to other NSF R&D data. The latest NSF-sponsored funder and performer-based survey data are available for state governments for fiscal year 1995. This survey was conducted by the Battelle Group and State Science and Technology Institute (SSTI). The relevant data from this survey for the Frascati-to-SNA link are the data on performance of R&D by state agencies and the state-funded performance of R&D by local governments. These data indicate for fiscal year 1995 that $408 million was spent within the state governments for the performance of R&D and $33 million of state funding was spent in local governments. These values are scaled up for 2001 with the growth rate of state and local government current expenditures from the NIPAs.[28] While the Batelle/SSTI survey provides the only aggregated source data identified for local government R&D activity, they represent only the component of local government R&D that was funded with state dollars.

[27] Brown, Plewes and Gerstein (2004) page 134.
[28] Table 3.3: 2001 value of 1368.2/1995 value of 978.2

The Batelle/SSTI survey provides an estimate of R&D plant that is consistent with that of federal government surveys. It includes facilities and fixed equipment, acquisition, construction, major repairs and alterations. It includes the acquisition of land and excludes movable equipment and equipment (Batelle and SSTI (1998) page 26). The equipment and software investment value is estimated with BEA sources as described earlier.

One adjustment is made to align the scope of state and local R&D to that of the Frascati/SNA framework. An estimated share of state and local expenditures for R&D that is devoted to commercialization is subtracted from R&D activity expenditures. The Frascati framework characterizes R&D activity with three subcomponents, basic research, applied research, and experimental development. This framework excludes certain related activities from the scope of R&D, including education, training, and marketing (OECD (2002) par. 66 -70) and tooling up for production processes (OECD (2002) Table 2.3). The Batelle/SSTI survey has a somewhat broader scope of R&D. In addition to basic research, applied research, and development, the survey includes commercialization as a valid component of R&D. For this survey, commercialization is "the reduction to practice of a technical idea, its incorporation into the design or production process of a product or service, and initial introduction of the product or service into a commercial market (Batelle and SSTI (1998) page 25).

The NSF is currently developing a prototype survey with the Census Bureau for state governments. This survey would provide information on the funding or performing state government agency, the source of the funds (federal or nonfederal), the recipients or performers of the R&D (intramural use or external industry, academia, or other nonprofit

organization), and the character of the R&D work (basic research, applied research, and development).

4.4. Private Non-profit and Household Sector

The scope of the Frascati-based Private Non-profit and Household sector is more limited than the SNA-based Non-profit Institutions Serving Households (NPISH) and Households sector because the Frascati sector does not include private non-profit colleges and universities. The SNA-based sector includes these private non-profit academic institutions, non-profit research institutes, R&D activity conducted by both membership and philanthropic associations that do not serve business, and the non-market R&D activity of households (OECD (2002) par. 194-197). No survey data are available for the non-market R&D activity of households, and it is considered to be small.

The NSF sponsored Gallop survey, Research and Development Funding and Performance by Nonprofit Organizations, was last conducted in fiscal 1996 and 1997 and has been discontinued. For more recent years, the Frascati-based expenditures for the U.S. are produced by the NSF with an imputation procedure (NSF (2001a)) using the data from the Federal Funds for R&D Survey and the last available survey values.

4.4.1. Non-profit institutions excluding Universities and Colleges

Adjusting for the scope of R&D conducted at non-profits in Table 9 on either a Frascati basis or NSF basis requires the inclusion of R&D in the humanities and the exclusion of R&D performed by non-profits that primarily serve business.[29] Non-profits that primarily serve business were identified on the last NSF sponsored Gallop survey,

[29] The discontinued survey for nonprofit organizations specifically excludes law, business administration/management science, humanities, most history, the arts, and most education (NSF (2003a), Appendix One).

Research and Development Funding and Performance by Nonprofit Organizations as trade associations and industrial consortiums, their expenditures are moved the non-financial business sector.

The discontinued non-profit survey provides very limited information for many of the adjustments required to translate the expenditures to an SNA basis. The adjustment for the purchase of R&D used as an intermediate input cannot be effectively made since the only relevant question includes pass-throughs as well as vendor relationships and contracts. There are no detailed questions on software or equipment purchases. As with the other sectors, consumption of fixed capital in the link table is estimated for this sector using BEA data.

4.4.2. Non-profit colleges and universities

The translation of Frascati-based expenditures for non-profit colleges and universities in Table 10 is based on the same academic survey as the public colleges and universities and described in section 4.3.3. After subtracting from total higher education expenditures (HERD) the expenditures for FFRDCs and for public colleges and universities, the steps are the same as described in Table 6.

4.5. Rest of World

Table 10, the Rest of the World sector, that accompanies this paper consolidates the import and export components from the other tables in order to provide a representation of the R&D flows between resident and non-resident units. While U.S. R&D survey data provides information on funders and performers of R&D, in general the non-resident characteristics of these funders and performers are not clearly identified.

From an SNA perspective, an import of R&D would be the purchase of R&D services from a non-resident entity, and an export would be the sale of R&D services to a non-resident entity. For the corporate sector BEA data are available for trade in R&D Services for affiliated (to U.S. multinational corporations) and unaffiliated Companies, but these export transactions may overlap with industrial performance data from the NSF.

5. Summary and further discussion

This paper has proposed a sectoring framework to translate existing NSF expenditure data on R&D activity into gross output of R&D on an SNA basis. This framework has been applied to U.S. survey data for R&D expenditures collected by the NSF. The sectoring framework adjusts for the differences between the sectors of the Frascati Manual and those of the SNA, and provides a conceptual basis to distinguish market R&D from nonmarket R&D given limited information about the R&D transactions characterized in the source data.

Because most of the R&D conducted in the U.S. is own account or non-market production, the translation of R&D expenditures to gross output is done by building up the cost components of the full value of production. The Frascati framework provides many of the components of cost needed for this translation, but not all. The largest missing component is consumption of fixed capital, which can be estimated well if good data exist on capital investment each year. An important feature of the Frascati framework is that it identifies the major components of gross fixed investment, structures, equipment, and software, as well as compensation costs. The latter is necessary when

R&D is capitalized in a satellite account develop to final estimates of value added by subtracting intermediate inputs from gross output.

While the Frascati-framework's careful avoidance of double-counting of R&D leaves a data gap for identifying R&D used as an intermediate input to the production of R&D, detail available from the SIRD allows these intermediate transactions to be identified for the financial and non-financial corporate sectors. The Frascati framework on performance and funding of R&D also obscures the nature of the economic transaction between funder and performer. The economic transactions that occur when the federal government funds R&D performed by others should ideally be identified so that grants, subsidies and transfers can be separated from intermediate purchases. While the Frascati Manual suggests a framework for international R&D flows, the focus of Frascati on domestic performance of R&D has thus far led to limited reporting of international transactions in R&D. Improving the estimates of trade in R&D services for all sectors would be a valuable improvement to the Frascati framework that would allow it to better translate to the SNA.

The final component of this project is to match the NSF source data to the SNA framework developed in the link tables. For most of the sectors, if the NSF data provided the detail called for in the Frascati-framework (separate measures of compensation, other current costs, investment in structures, investment in equipment, and investment in software), the translation process would be significantly improved.

While sectors like the non-profits and state and local government that perform a smaller component of U.S. R&D are covered infrequently by NSF surveys, the largest components of U.S. R&D performance, that conducted by private industry, universities

and colleges, and the agencies of the federal government, are covered by good annual surveys. In addition to information about capital expenditures, improved detail on expensed software and equipment would be helpful for all of these surveys. Greater understanding of the role of purchased and own-account software in the R&D process would improve the estimates of all sectors. For all of the NSF surveys, some of the most useful information for developing estimates of R&D capital stock would ask respondents for annual capital expenditures for structures, equipment and software, but this has been described as some of the most burdensome information for respondents to provide.[30]

[30] Brown, Plewes and Gerstein (2004) page 134.

6. Appendix: Financial Sector NAICs codes

ISIC		NAICS	
6511	Central banking	521110	Monetary Authorities-Central Bank
6519	Other monetary intermediation	522110	Commercial Banking
6519	Other monetary intermediation	522120	Savings Institutions
6519	Other monetary intermediation	522130	Credit Unions
6519	Other monetary intermediation	522190	Other Depository Credit Intermediation
6592	Other credit granting	522210	Credit Card Issuing
6591	Financial leasing	522220	Sales Financing
6592	Other credit granting	522220	Sales Financing
6592	Other credit granting	522291	Consumer Lending
6592	Other credit granting	522292	Real Estate Credit
6592	Other credit granting	522293	International Trade Financing
6592	Other credit granting	522294	Secondary Market Financing
6592	Other credit granting	522298	All Other Nondepository Credit Intermediation
6511	Central banking	522298	All Other Nondepository Credit Intermediation
6719	Activities auxiliary to financial intermediation n.e.c.	522310	Mortgage and Nonmortgage Loan Brokers
6719	Activities auxiliary to financial intermediation n.e.c.	522320	Financial Transactions Processing, Reserve, and Clearinghouse Activities
6719	Activities auxiliary to financial intermediation n.e.c.	522390	Other Activities Related to Credit Intermediation
6599	Other financial intermediation n.e.c.	523110	Investment Banking and Securities Dealing
6712	Security dealing activities	523120	Securities Brokerage
6719	Activities auxiliary to financial intermediation n.e.c.	523130	Commodity Contracts Dealing
6599	Other financial intermediation n.e.c.	523130	Commodity Contracts Dealing
6712	Security dealing activities	523140	Commodity Contracts Brokerage
6711	Administration of financial markets	523210	Securities and Commodity Exchanges

Financial Sector NAICs codes (continued)

6592	Other credit granting	523910	Miscellaneous Intermediation
6599	Other financial intermediation n.e.c.	523910	Miscellaneous Intermediation
7010	Real estate activities with own or leased property	523910	Miscellaneous Intermediation
6602	Pension funding	523920	Portfolio Management
6712	Security dealing activities	523920	Portfolio Management
6719	Activities auxiliary to financial intermediation n.e.c.	523930	Investment Advice
6599	Other financial intermediation n.e.c.	523991	Trust, Fiduciary, and Custody Activities
6719	Activities auxiliary to financial intermediation n.e.c.	523991	Trust, Fiduciary, and Custody Activities
6712	Security dealing activities	523999	Miscellaneous Financial Investment Activities
6719	Activities auxiliary to financial intermediation n.e.c.	523999	Miscellaneous Financial Investment Activities
6601	Life insurance	524113	Direct Life Insurance Carriers
6603	Non-life insurance	524113	Direct Life Insurance Carriers
6603	Non-life insurance	524114	Direct Health and Medical Insurance Carriers
6603	Non-life insurance	524126	Direct Property and Causality Insurance Carriers
6603	Non-life insurance	524127	Direct Title Insurance Carriers
6603	Non-life insurance	524128	Other Direct Insurance (except Life, Health, and Medical) Carriers
6601	Life insurance	524130	Reinsurance Carriers
6603	Non-life insurance	524130	Reinsurance Carriers
6720	Activities auxiliary to insurance and pension funding	524210	Insurance Agencies and Brokerages
6720	Activities auxiliary to insurance and pension funding	524291	Claims Adjusting
6720	Activities auxiliary to insurance and pension funding	524292	Third Party Administration of Insurance and Pension Funds
6720	Activities auxiliary to insurance and pension funding	524298	All Other Insurance Related Activities
	Pension Funds	525110	pension funds (excluding compulsory social security) legal entities
	Health and Welfare Funds	525120	employee vacation funds, Christmas funds, etc., self insurance for health and welfare
	Other Insurance Funds	525190	life insurance funds (self insurance) solely for the benefit of the sponsor, firm, its

			employees or members, other self insurance funds
	Open-End Investment Funds	525910	open-ended money market mutual funds, open-ended mutual funds, etc.
	Trusts, Estates, and Agency Accounts	525920	trusts, estates, and agency accounts
	Real Estate Investment Trusts	525930	real estate investment trusts (REITs)
	Other Financial Vehicles	525990	closed-end funds

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